HOW DOES SAVINGS RATE AFFECT ECONOMIC GROWTH?

ECONOMETRIC ANALYSIS 3161

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Table of Contents

Abstract

The following paper focuses on determining how the savings rate affects the economic growth in terms of income by analyzing a cross section data of 100 countries in 2010. In order to infer the relationship between these two variables, two types of studies are conducted: simple and multiple regressions. For the simple regression analysis between savings rate and income, it is shown that these two variables are positively correlated with a coefficient of correlation of about 25% indicating that there are other explanatory variables that should be taken into account when evaluating the disparities in income across countries. The first multiple regression analysis conducted replicates the studies found in "A Contribution to the Empirics of Economic Growth" (Mankiw, Gregory, Romer, Weil, 1992). For this analysis, population growth rate and education are introduced as explanatory variables, leading to a coefficient of correlation of 71%. Furthermore, our study introduces one more explanatory variable of number of science journals published as an indicative of technology growth in each country. For this analysis the correlation coefficient obtained is 72%, showing that the introduction of the new variable did not significantly contribute to the explanation of income disparities. Finally, the countries are divided into high and low-middle income in order to determine if the relationship between savings rate and income is altered by this factor. It is observed that the relationship still holds true for both cases and it is proved that technology growth is statistically significant for middle-low income countries whereas for high-income countries it is insignificant. It can be concluded that savings rate, education index and technology are positively correlated to income whereas population growth is negatively correlated to the dependent variable. In order to better understand and explain these relationships it is recommended to look into other indicators of technology that have a higher statistical significance in the model.

1. Introduction

This project is motivated by the eagerness to understand the significant differences in economic growth across countries. From a personal standpoint, the fact that we were born and raised in underdeveloped countries has made us inquire about the causes of economic growth and the differences in the growth rate between countries. For this reason, this research project focuses in uncovering those factors that truly influence economic growth in countries.

This project uses as a basis the Solow Model, which explains the long-run economic growth by looking at capital accumulation. This model states that as countries first begin to accumulate capital, their economic growth is strong; but as this process of capital accumulation continues, economic growth slows down. In this paper, we examine the current validity of the Solow-Growth Model in explaining the cross-country differences in income by replicating the study done by Mankiw, Gregory, Romer, and Weil in 1992. In this study, income is analyzed in terms of savings rate, education and population growth, where technological growth is considered to be constant throughout countries.

For our research project we include technological growth as an explanatory variable in order to account for the differences in development between nations. This being said, we assume that although at a decreasing rate, savings rate has a positive impact on income. Also, in the inclusion of other explanatory variables, we assume that technology and education are positively correlated to economic growth, while population growth rate has a negative impact on it. Additionally we assume that technological growth rate will have a significant impact on economic growth, contrary to the assumption in the study from 1992, where this variable is considered to be exogenous.

This paper is comprised of 4 sections. The first section uses literature findings to describe the relationship between the variables mentioned and explains the previous study done in 1992. The second section shows a simple regression analysis of savings rate and income by looking at 100 countries in 2010. In the third part of this paper we aim to uncover the ceteris paribus effect by adding the variables of education, technological growth rate and population growth rate. Finally, the last section of this paper makes a comparison between high- income and low-middle income countries to determine if the relationship between economic growth and savings is affected by the nations' income.

2. Literature Review

There is an extensive body of literature regarding the relation between the savings rate and the growth in GNI, following the Solow Model, using a time-series data analysis across countries. Studies that could help model our assumptions into a cross-country model in a single period of time, are really scarce.

Nonetheless there is literature available that describes the inverse relation between the population growth of a country and the ratio of GNI over unit of labor. Also, there is literature describing the positive relation between education and GNI per capita and between the technology growth and GNI per capita. The latter does not exactly describe the proxy we used as technology growth rate, which is the number of science journals published, but is still a good indicator of the overall relationship between technology and economic growth.

2.1. Savings and GNI growth per unit of labor

Edwards (1995) uses 16 countries from different countries over the world across a different time frame until 1992, to show the evolution of national savings across several years for several regions of the world. Using a time-series analysis, it is found that there is a relationship between growth and savings. Empirically there are two schools of thought that differ on the direction of this relationship between growth and savings. Modigliani (1970) argues that in a life-cycle setting, there is going to be a positive relation between growth and savings. On the other hand, Bosworth (1993) pointed out that there is also a negative effect, as workers in a growing economy will anticipate future income increases, and increase present consumption, thus decreasing savings.

Andrei and Huidumac-Petrescu (2013) used a panel data analysis in 17 countries from the Euro Area in a time frame that spun from 2000 to 2011. In their findings, they analyze the relationship between real GDP growth and national savings in a time frame before and after the Euro crisis. Here they find that there is a positive relationship between growth and savings in the long term, as there is a delay of four years. In other words, the higher the GNI, the higher savings are going to be in the country. The only singularities they find are Cyprus, Portugal, Greece and Malta; where, although the same positive relationship is found, the intensity is low. This can be shown due to the difference in structural parameters, such as political stability, between these four countries, and the rest of the Euro Area.

2.2. Population Growth and GNI growth per unit of labor

For decades, economists have debated if population growth restricts, improves or has no effect on economic growth (which can be extrapolated to GNI), but Bloom, Canning and Sevilla (2001) focus on how population growth has a negative impact on economic growth.

In their paper they discuss how growth in population has a positive impact on economic growth in the short term, but in the medium and long term it becomes harmful for a country's economy. As capital is almost fixed in an economy, or in other words, it does not grow as fast as population, the distribution of money and income per unit of labor is going to decrease, which can lead to an increase in income disparities. Latin America in the 60's proved this as increases in life expectancy increased the population in an extreme way.

2.3. Human Capital and GNI growth per unit of labor

One of the best indicators of human capital is education. Krueger and Lindahl (2000) talk about the direct relation between GNI and education. They explain how the level of education, since pre-school to secondary school increases the level of prepared labor. "... Schooling could change the steady-state growth rate by enabling the workforce to develop, implement and adopt new technologies." This represents an increase in productivity for countries, and since wages are based on productivity of the market, there is be an increase in the income per unit of labor.

2.4.Technology growth and GNI growth per unit of labor

GNI is mostly based on wages received by each labor unit. There is a high relationship between the wages in a specific sector and the productivity of such sector. According to the study by Bartel, Ichniowski and Shaw (2005), there is a direct relationship between investment in technology in a country and the increase in productivity. As law of diminishing returns, there is a higher impact of technological growth in unproductive countries than in productive countries. As productivity in a country increases, there is an increase in that country's national wages, therefore GNI increases.

In our model we used a proxy, which is the number of journals published in each country per year, in order to measure technology in such country.

2.5. Replicated Study

Mankiw, Gregory, Romer and Weil (1992) make a study classifying 3 subgroups of countries. The first one having 98 countries that does not include oil producers, the 2nd one having 75 countries with a population that does not exceed 1 million, and the 3rd group containing 22 countries that are OECD members with a population of more than 1 million. The study is a cross-reference between these countries in two different years: 1960 and 1985. In this study the regression function starts basing off from a Cobb-Douglas production function, and being derived until a regression function, which resembles the Solow Model, is achieved. This function is based in the following parameters: Income per unit of labor as a function of the rate of savings, and the rate of population growth, technology, depreciation and human capital. Technology and depreciation are considered constant throughout the

countries in the three samples of the experiment. The findings that support the Solow Model in this experiment were three: the coefficients on savings and population growth were both correct (Positive and negative), the assumption that the coefficient on savings and the sum of population growth, technology and depreciation are opposite in sign in not rejected by the data samples, lastly the differences in savings and population growth account for a large fraction of the cross-country variation in income per capita.

There seems to be strong evidence of the direct relationship in the long run between these two macroeconomic variables, GNI growth and national savings. In this paper we test this relationship by trying to replicate the Mankiw, Gregory, Romer and Weil (1992) study for countries in 2010 in order to generate a cross-reference study for the effect of the savings rate in GDP growth in a short period of time. Following the Solow Model we want to contribute to the understanding of how this long run relationship between GNI growth and national savings can be seen as well in a short period of time.

2.6. Contribution

In this paper we were able to contribute with a challenge to the assumption made by the study, which is that the technology factor is constant across countries. The results obtained show that technology factors have an insignificant effect on countries with high income, but do show some effect on low and medium income countries. This shows that the assumption of assuming technology as exogenous won't affect the overall results for GNI per unit of labor.

3. Data

3. 1 Solow-growth Model from 1992 Research Study

The Simple Solow-growth model assumes a simple Cobb-Douglass function with three factors of technology, labor and capital, resulting in: $Y(t) = K(t)^{\alpha} (A(t) L(t))^{1-\alpha}$ However, the extended version of the model from the 1992 study, adds human capital as another explanatory variable, leading to the following model:

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} (A(t) L(t))^{1-\alpha-\beta}.$$

This model assumes that steady state has already been achieved, in order to identify if cross-countries levels of income are affected by savings rate.

Another adjustment made to the model is the normalization of population size, achieved by dividing income by labor, leading to:

$$LN(Y/L) = B_0 + B_1 LN(s) + B_2 LN(n + g + d) + B_3 LN(h)$$

Where,

n = population growth rate
g = technological growth rate (assumed to be constant)
d =depreciation rate (assumed to be constant)
s =saving rate (Defined as the investment divided by real GDP)
Y = level of income (GNI)
L = total labor force
h = human capital (Used a proxy of the UN measuring the mean years of schooling and expected years of schooling)

It is important to highlight that B_0 becomes slightly important here because it absorbs the error term u, which in this case would be the country specific shock.

3.2 Adjustments to Model

For our study we eliminated the variable of depreciation rate and challenged the assumption of a constant technological growth rate by adding a new explanatory variable of number of science journals published by country. These adjustment lead to our model from which we based all the analysis:

$$LN(Y/L) = B_0 + B_1 LN(s) + B_2 LN(n) + B_3 LN(h) + B_4 LN(g)$$

Where,

n = population growth rate
g = technological growth rate
s =saving rate (Defined as the investment divided by real GDP)
Y = level of income (GNI)
L = total labor force
h = human capital (Used a proxy of the UN measuring the mean years of schooling and expected years of schooling)

3.3 Sources of Data

For this analysis, the data for income, labor, technology and savings were obtained from the World Data Bank. Additionally, the population growth rate and human capital data were obtained from the IndexMundi and the United Nations, respectively.

3.4 Descriptive Statistics

These descriptive are for the initial model including all the data gathered:

Variable	Obs	Mean	Std. Dev.	Min	Max
countryname	0				
lngnilabor	100	9.239066	1.524355	6.580611	12.00329
lnsavings	100	2.802619	.9002159	-.5291532	4.452134
lnpopg	100	.1108326	.9588121	-3.506558	1.595339
lneducatio~x	100	4.205463	.266021	3.304034	4.60517
lntech	100	4.066112	2.772256	-2.207275	11.50099
hvslm	100	.7	.4605662	0	1

The following are the descriptive statistics for high and low and middle income countries:

High Income Countries

Variable	Obs	Mean	Std. Dev.	Min	Max
countryname	0				
lngnilabor	30	9.785952	1.590015	6.882628	12.00329
lnsavings	30	2.825262	1.074501	-.5291532	4.452134
lnpopg	30	-.0324184	1.120909	-2.813411	1.595339
lneducatio~x	30	4.261804	.303583	3.304034	4.60517
lntech	30	4.126321	3.208308	-2.207275	9.645684
hvslm	30	0	0	0	0

Low, Middle Income Countries

Variable	Obs	Mean	Std. Dev.	Min	Max
countryname	0				
lngnilabor	70	9.004687	1.444169	6.580611	11.49145
lnsavings	70	2.792915	.822901	.5798038	4.011295
lnpopg	70	.1722259	.8821631	-3.506558	1.156881
lneducatio~x	70	4.181317	.2466351	3.616906	4.60517
lntech	70	4.040309	2.588143	.0506931	11.50099
hvslm	70	1	0	1	1

It is important to highlight that the mean in the population growth rate for the High Income countries is negative while the mean population for low-income countries is positive.

3.5 Gauss Markov Assumptions

1) Linear parameters

This assumption is not violated as it is demonstrated in section 3.2 with the explanation of the model and the corresponding control and response variables.

2) Random sampling

The data collected was done for all the possible countries that had entries for the desired categories. From this set of countries, the central planned economies where eliminated leading to a total sample of 100 observations. Using the metadata provided, the countries where separated into two categories Low and Middle Income and High Income. The High Income group corresponds to the "OECD: High Income" and "Non-OECD: High Income". The rest of the countries that didn't meet the requirements to fit into those categories were classified as Low and Middle Income. From the way in which the data was collected it can be seen that any possible biasness was intended to be avoided.

Nonetheless, there are 196 recognized countries and nearly half the population data set is missing mostly for severe underdeveloped countries. Additionally since most of our data was collected from the World Bank any biasness and flaws in the randomness is reflected in the results.

3) No Perfect Collinearity

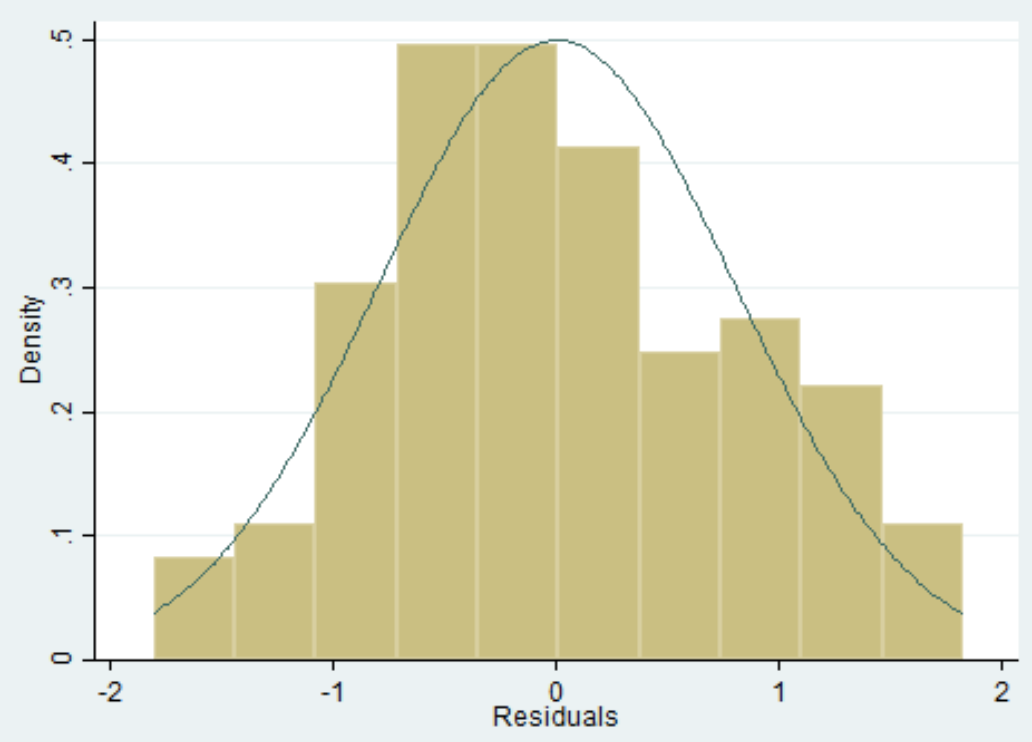
In order to prove this assumption, a correlation matrix was produced:

	lnsavi~s	lnpopg	lneduc~x	lntech
lnsavings	1.0000			
lnpopg	-0.0913	1.0000		
lneducatio~x	0.3419	-0.5733	1.0000	
lntech	0.3081	-0.4841	0.5804	1.0000

Savings rate and population growth rate have a high inverse correlation. However in the textbook Solow Model the coefficients B_1 and B_2 are supposed to be equal in magnitude but with opposite signs thus this high inverse correlation is actually a positive reinforcement of textbook Solow and it is of no concern.

4) Zero conditional Mean

Using the equation in the all countries regression the residuals were calculated and plotted in a Histogram as shown below:



Looking at the histogram it does seem to have a slight skew to the left however not enough so that it violates the normality assumption

4. Results

For this analysis, different regressions where ran in order to explore the explanatory power of the particular variables in the cross-country level of income difference.

4.1 Simple Regression Analysis

The first regression is a simple regression on all countries focusing on the underlying hypothesis of the Solow model: Savings rate influences the level income.

Source	SS	df	MS	Number of obs =	100
Model	58.4505066	1	58.4505066	F(1, 98) =	33.38
Residual	171.591784	98	1.75093657	Prob > F =	0.0000
				R-squared =	0.2541
				Adj R-squared =	0.2465
Total	230.042291	99	2.3236595	Root MSE =	1.3232

lngnilabor	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnsavings	.8535518	.1477308	5.78	0.000	.5603849	1.146719
_cons	6.846886	.4346639	15.75	0.000	5.98431	7.709462

From the Model's P value 0.0000 and the B_1 p value 0.000 we can confirm that Savings Rate is statistically significant at alpha levels of 5,10 and 5%.

4.2 Multiple Regression Analyses

4.2.1 Replicate Model

The first multiple regression regression attempts to reproduce the results that Mankiw, Gregory, Romer and Weil obtained in their paper "A Contribution to the Empirics of Economic Growth", where they examined the cross country difference of the Solow Model using an extended version with human capital.

Source	SS	df	MS	Number of obs =	100
Model	164.961023	3	54.9870075	F(3, 96) =	81.11
Residual	65.081268	96	.677929875	Prob > F =	0.0000
				R-squared =	0.7171
				Adj R-squared =	0.7082
Total	230.042291	99	2.3236595	Root MSE =	.82336

lngnilabor	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnsavings	.4961634	.0987351	5.03	0.000	.3001758	.692151
lnpopg	-.3635997	.1063209	-3.42	0.001	-.5746451	-.1525543
lneducationindex	3.187299	.406079	7.85	0.000	2.381238	3.993359
_cons	-5.515259	1.639191	-3.36	0.001	-8.769026	-2.261491

The results are interesting. First we take a look at the R-squared, it is 71%, relatively close to the R-squared obtained in the 1992 study, which was of 78%. Again the Model's p-value (0.0000) and the three variables Savings Rate (0.000), Population growth (0.001) and

Human Capital (0.000), where Education Index used as proxy are all statistically significant at alpha levels of 5,10 and 15%. We can further assert this by looking at the 95% confidence interval; 0 does not fall between any of the ranges for any variable.

4.2.2 Our Model

In their paper Mankiw, Gregory, Romer and Weil assume technological progress rate is constant for all countries. The following regression challenges that assumption. Using the Technological proxy identified in the Data Section a regression was run.

Source	SS	df	MS		
Model	166.814286	4	41.7035716	Number of obs =	100
Residual	63.2280041	95	.665557938	F(4, 95) =	62.66
				Prob > F =	0.0000
Total	230.042291	99	2.3236595	R-squared =	0.7251
				Adj R-squared =	0.7136
				Root MSE =	.81582

lngnilabor	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnsavings	.4662023	.099464	4.69	0.000	.2687413	.6636633
lnpopg	-.3179734	.1088369	-2.92	0.004	-.5340419	-.101905
lneducationindex	2.933535	.4301361	6.82	0.000	2.079607	3.787463
lntech	.0632694	.0379156	1.67	0.098	-.0120026	.1385414
_cons	-4.626414	1.70928	-2.71	0.008	-8.019763	-1.233065

It can be seen that R-squared adjusted increased by less than 1%, which is not a significant change. Meanwhile the p-value for the Model (0.0000) and the variables savings rate (0.000) population growth (0.004) and technological process (0.098) and human capital (0.000) they all remain significant at alpha levels of 10 and 15%. However, human capital, savings rate and population growth rate remained significant at alpha levels of 5% but technological progress did not.

Further analysis into the distinction between the Cross-Country differences was taken and the regression was run for two separate groups: High Income, and Low- Middle Income.

4.2.3 Regression for High Income Countries

Source	SS	df	MS
Model	56.8926653	4	14.2231663
Residual	16.4236091	25	.656944363
Total	73.3162743	29	2.52814739

Number of obs	30
F(4, 25)	21.65
Prob > F	0.0000
R-squared	0.7760
Adj R-squared	0.7401
Root MSE	.81052

lngnilabor	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnsavings	.5522592	.1556746	3.55	0.002	.2316413	.8728772
lnpopg	-.2174677	.1762628	-1.23	0.229	-.5804877	.1455524
lneducationindex	2.854411	.7214873	3.96	0.001	1.36848	4.340342
lntech	.0454254	.0641175	0.71	0.485	-.0866271	.1774779
_cons	-4.133752	2.87183	-1.44	0.162	-10.0484	1.780892

From the regression with High Income there is one important thing to notice, the p-values for Population Growth and Technology increased to 0.229 and 0.485, which means that they are no longer statistically significant at an alpha level of 5,10 or 15%, which was not the case for the regression including all countries.

Furthermore, a restrained model without Technology or Population growth regression was run for the High Income group to be able to perform a partial F-test. Before the test H_o and H_a are defined as:

$H_{o:}$ B (Technological Rate) = B (Population Growth) =0

H_a: At least 1 (between B (Technological Rate) and B (Population Growth) do not equal 0.

Source	SS	df	MS
Model	55.1070205	2	27.5535102
Residual	18.2092538	27	.674416809
Total	73.3162743	29	2.52814739

Number of obs	30
F(2, 27)	40.86
Prob > F	0.0000
R-squared	0.7516
Adj R-squared	0.7332
Root MSE	.82123

lngnilabor	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnsavings	.5089797	.1488016	3.42	0.002	.203664	.8142954
lneducationindex	3.661774	.5266683	6.95	0.000	2.58114	4.742408
_cons	-7.257811	2.161056	-3.36	0.002	-11.69193	-2.823692

The computed F value is 1.30469, while the F value obtained at alpha=10% is 2.53833, showing that we fail to reject the Null Hypothesis and thus determine that for this model Technological Growth Rate and Population Growth Rate are jointly insignificant.

4.2.4 Low-Middle Income Countries

Furthermore, the regression for Middle and Low Income is as follows:

Source	SS	df	MS
Model	103.146552	4	25.7866379
Residual	40.7615654	65	.627101005
Total	143.908117	69	2.08562489

Number of obs	= 70
F(4, 65)	= 41.12
Prob > F	= 0.0000
R-squared	= 0.7168
Adj R-squared	= 0.6993
Root MSE	= .7919

lngnilabor	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnsavings	.3873876	.1269005	3.05	0.003	.1339497	.6408255
lnpopg	-.3828219	.1354728	-2.83	0.006	-.6533797	-.1122641
lneducationindex	2.767155	.5264125	5.26	0.000	1.715836	3.818473
lntech	.089299	.0459035	1.95	0.056	-.0023765	.1809746
_cons	-3.94247	2.094248	-1.88	0.064	-8.124973	.2400333

The regression for the Middle and Low Income group is quite different from the regression with only High Income countries. The variables p-values are savings rate (0.003), population growth (0.006), human capital (0.000) and technological growth (0.056) indicating that they all statically significant at alpha levels of 10 and 15%. Additionally, all variables are statistically significant at an alpha level of 5% except technological growth rate.

5. Conclusions

It has been proved that as expected, savings rate has a positive impact on income for all the countries observed in 2010. This relationship still holds true for the countries classified in low-middle income as well as those in the high-income category. Therefore, we are reassuring our initial hypothesis, where savings rate and economic growth are positively correlated and thus savings rate plays a significant role in the income disparities across countries. From the simple regression analysis conducted we obtained a correlation coefficient of about 25% showing that savings rate is not the only cause of income disparities in nations. Furthermore, the model that replicated the 1992 study by Mankiw, Gregory, Romer and Weil, showed a correlation coefficient of 71%. From this analysis it can be seen how human capital and technological growth rate are positively correlated to income whereas population growth rate has a negative impact on income. Additionally, we tested our modified model where we challenged the assumption that technological growth rate is constant, and obtained some unexpected results. The correlation coefficient increased by only 1%, showing that the number of science journals published, which was used as an estimator for technological growth rate, does not have a high impact on income.

By taking a closer look to all the control variables it can be seen that savings rate and human capital are statistically significant at all levels in all the multiple regression analyses, showing that both play a significant role in the inequalities in income between nations. Furthermore, population growth rate came out to be more significant for low-middle countries rather than for the high income ones as shown by the p values from section 4.2.3 and 4.2.4. This can be attributed to the fact that the mean population growth for high-income countries is negative while the mean for low-middle income countries is positive as proved by the descriptive statistics in section 3.4. Given that population growth rate has a negative impact on income, the fact that there is negative population growth for high-income countries leads to a negative impact on income with much less intensity than the one present in the low-middle countries where the population growth is higher. Moreover, even though technological growth rate proved to not to be too influential in the income disparities, it has a higher statistical significance for the low-middle countries. This is due to the fact that there is not a significant difference in technology among high-income countries and therefore the differences in income won't be affected by this factor. On the other hand, the differences in technology among low-middle income countries are higher, and therefore have a higher significance in explaining income differences for those countries.

This study was able to prove the initial hypothesis where we stated that after countries reach a steady state, the higher the savings rate the greater the economic growth. Also, our hypothesis was correct in the determination of the relationships between the dependent variable of income and the independent variables of population growth, technology and education. Additionally, technological growth rate was proved to be somewhat significant for the multiple regression analyses for all countries and for the low-middle income countries, indicating that this factor should not be considered exogenous as it

was considered for the 1992 study by Mankiw, Gregory, Romer and Weil. Nonetheless, other estimators for technological growth rate should be used that hold significant at all levels for all the categories, proving a consistent positive impact on economic growth in countries.

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